MASSACHUSETTS BAYS NATIONAL ESTUARY PROGRAM

May 2006 Extreme Rain Event and the Response of the Coastal Waters in the Massachusetts Bays System

May 26, 2006

Record rains fell on coastal communities in Massachusetts and New Hampshire beginning in the second week of May 2006. Public information statements released by the National Weather Service shortly after this event reported that Boston had 8.49 inches occurring over four calendar days ending May 16. This is the fourth highest 4-day total among records dating back to 1872. The Merrimack River watershed (to the north and west of Boston) received even greater rainfall totals than Boston—some 13-15 inches were recorded in towns from Marblehead to Newburyport. Using 6-day rainfall totals of data[1] contained within the dashed box in Figure 1 (roughly 10,000 mi^2), we estimate that approximately 1.3 trillion gallons fell onto the area north of Boston.

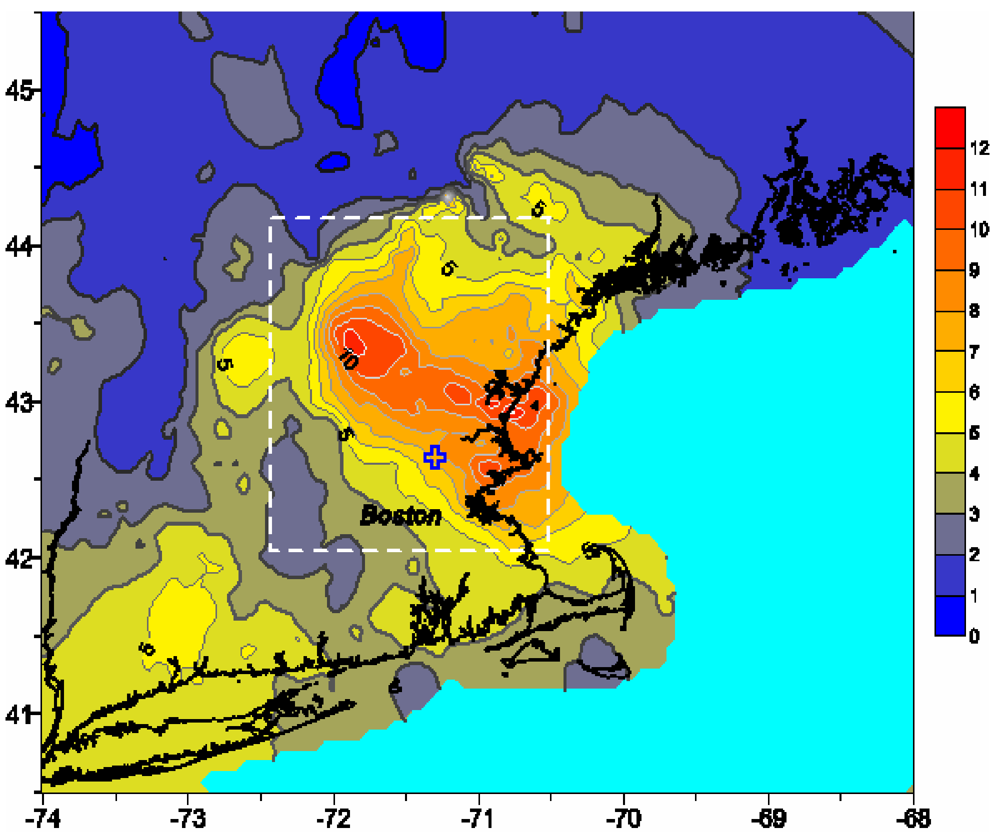


Figure 1. Rainfall amounts totaled from stations reporting to the National Weather Service for the period of May 12-17, 2006. National Weather Service data were obtained from 4,828 stations that reported for each of the 6 days. The USGS streamflow gage in the lower Merrimack River is shown by the blue cross.

[1] Rainfall data were derived from National Weather Service River Forecast Centers (RFCs) using data reported at stations for six consecutive days. http://www.srh.noaa.gov/rfcshare/precip_analysis_new.php

Impact to Massachusetts Bay

Freshwater input into Massachusetts Bay is dominated by outflow from the Merrimack River which empties into the coastal waters to the north of Cape Ann. The response of the Merrimack River, as recorded by the U.S. Geological Survey (USGS) streamflow gage located near Lowell, MA during this period is shown in Figure 2 below. Peak flow occurred at 7:00 p.m. on May 15th was the 3rd highest recorded on record (beginning in 1923). The river continued to run well above historical discharge rates two weeks after the rains began (Figure 2). New historical high peak discharges were also recorded at stations along the Ipswich River (USGS Stations 01101500 and 01102000) and in the Saugus River near the Saugus Iron Works (USGS Station 01102345). An overview of the May 2006 flooding in Massachusetts by the USGS can be found in their press release dated May 22 2006 (http://www.usgs.gov/newsroom/article_pf.asp?ID=1510).

A hydrodynamic model of the coastal waters of the Massachusetts Bays system, maintained by the University of Massachusetts/Boston (http://www.harbor1.umb.edu/), provides daily surface salinity predictions that show a pronounced presence of the freshwater plume from the Merrimack River in the coast waters north of Cape Ann beginning on May 16th (Figure 3). The maximum spatial extent of the plume was predicted to occur over the next few days, reaching beyond Cape Ann by May 18th, and moving into the near coastal region to the south over the following week. According to the model, the plume remains well-defined as of this writing. The location and dispersion of the Merrimack plume into Massachusetts Bays are strongly influenced by wind direction and strength. Winds were predominantly from the south on May 18-19, favoring offshore transport of the plume into the more open Massachusetts Bay waters. Data from the Gulf of Maine Ocean Observing System buoy located in western Massachusetts Bay just to the south of Cape Ann corroborate the Massachusetts Bays Model, showing distinct depressions in surface water salinity, most notably between the period of May 16-18, and again for periods between May 21-23 (Figure 4). Oceanographic surveys following this rain event are being conducted by MWRA, WHOI, and others that will help to validate the model predictions.

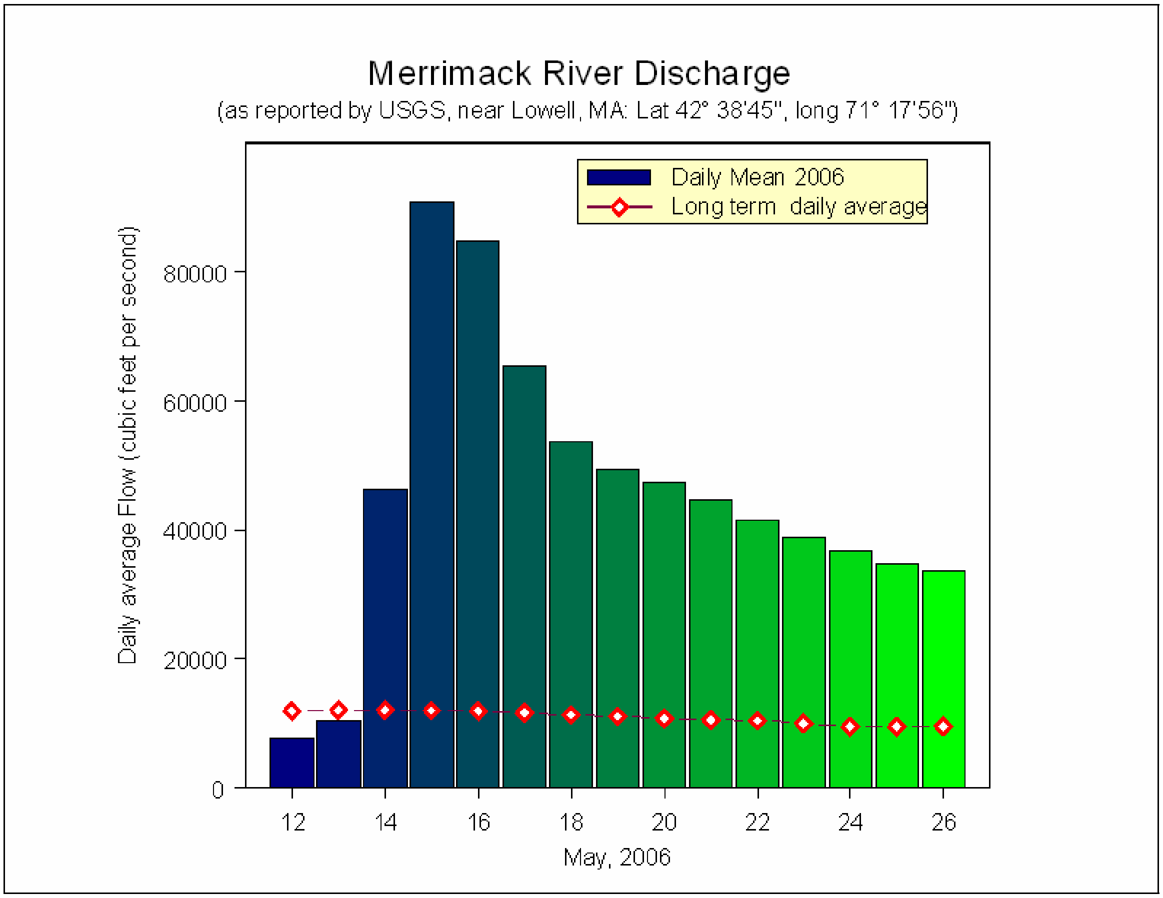
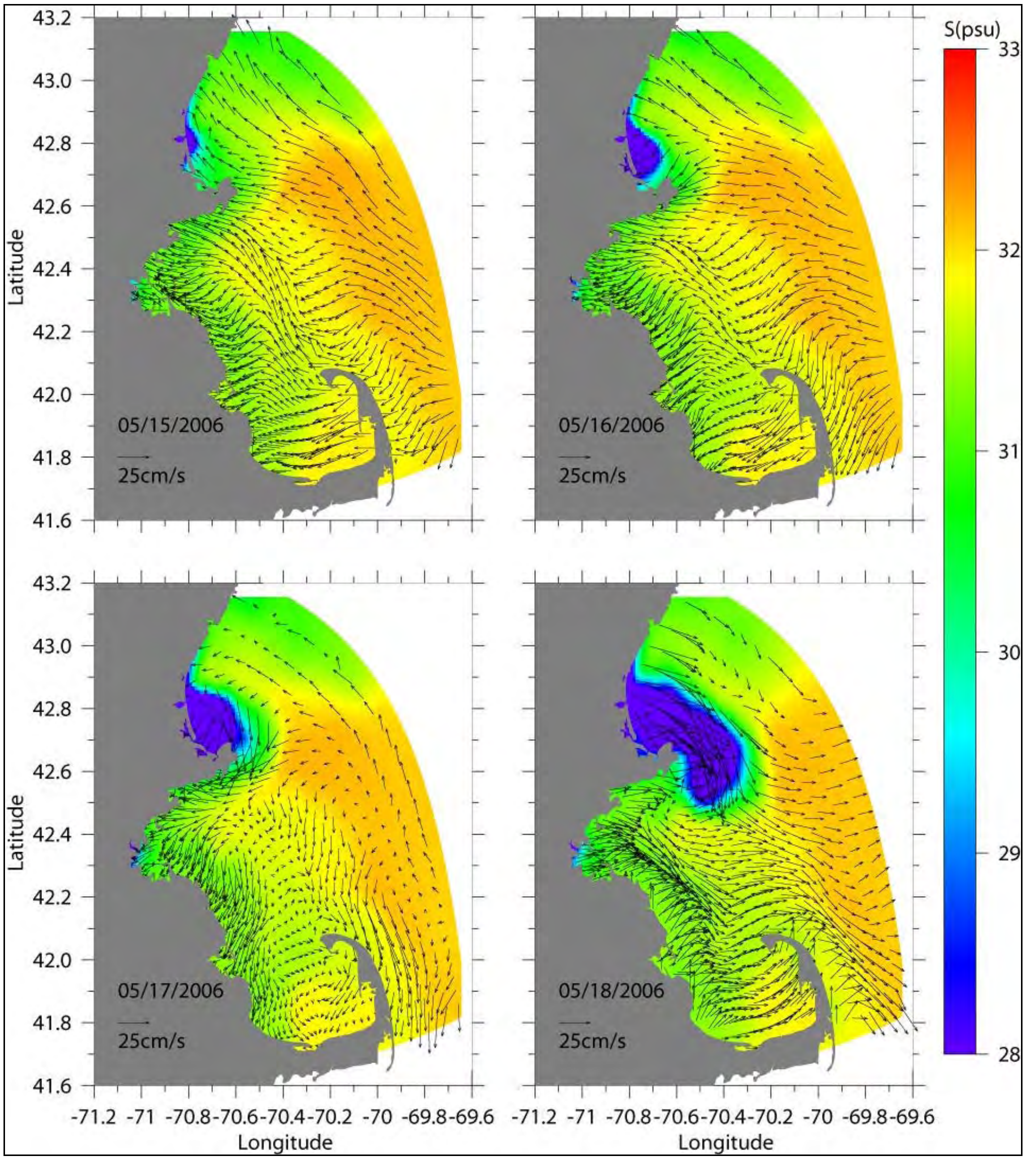


Figure 2. Flows in the Merrimack River recorded at the USGS streamflow-gaging station (0110000) below the confluence with the Concord River, during the period of May 12-26, 2006. Provisional flow data were obtained from http://waterdata.usgs.gov/ma/nwis/uv?01100000.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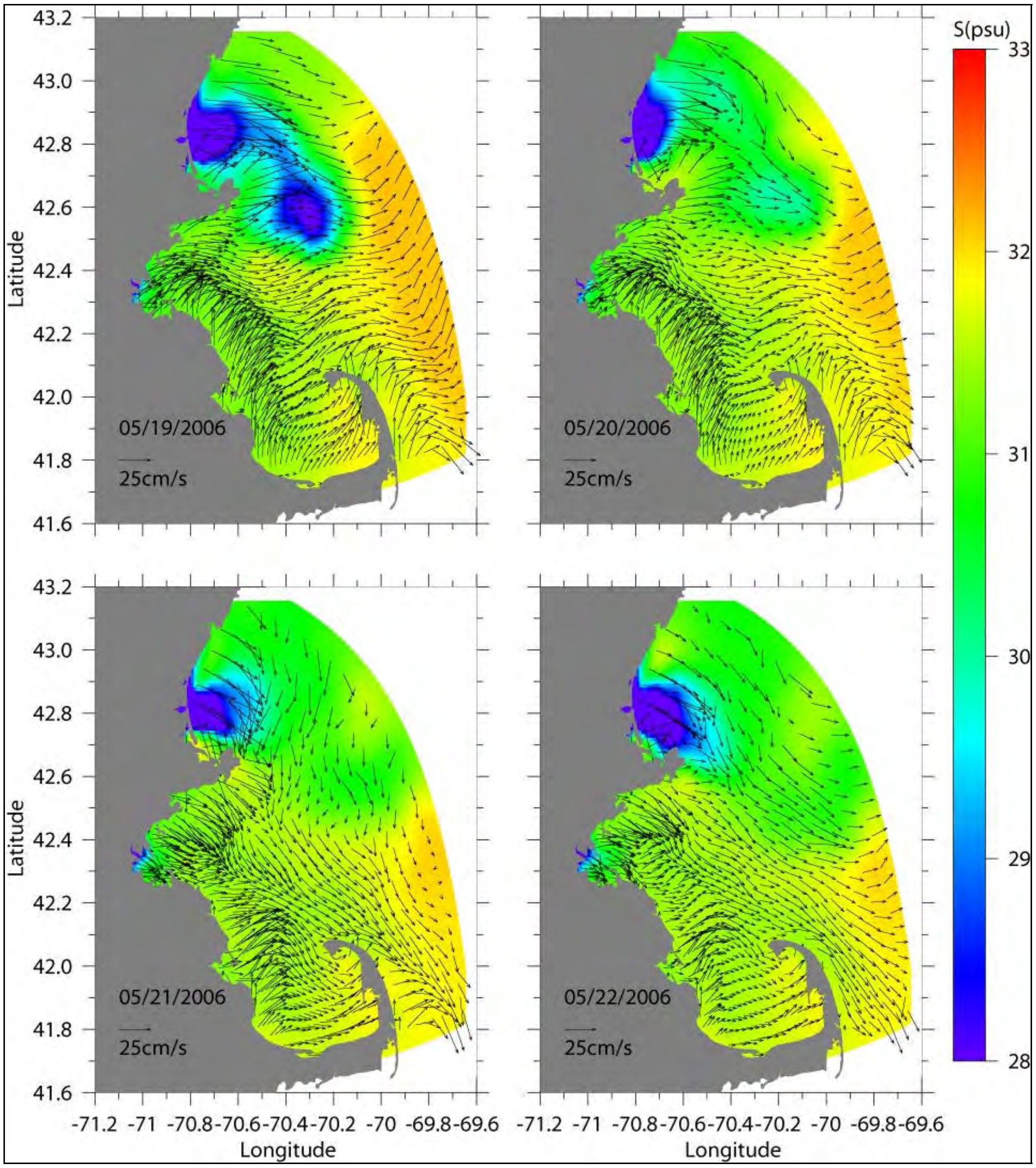

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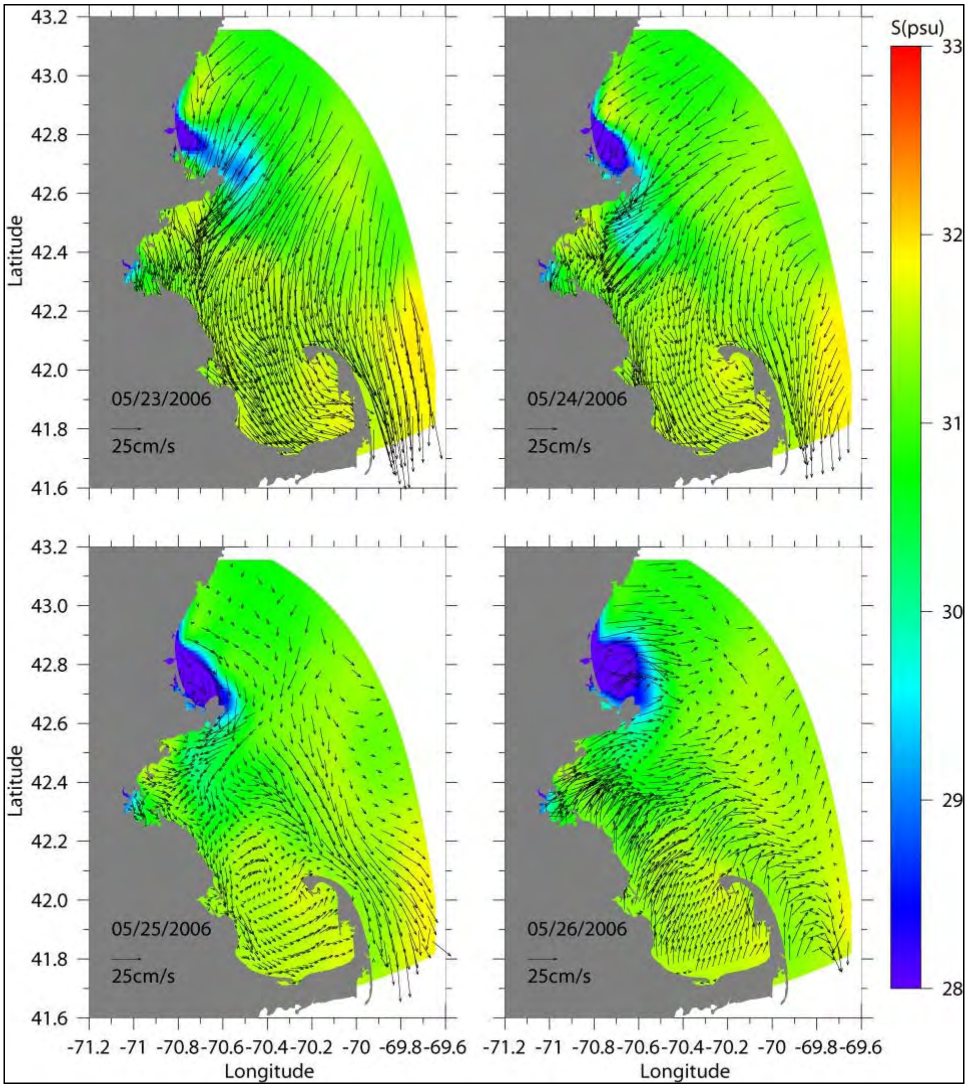

Figure 3. Massachusetts Bays Model daily average predictions of surface salinity distributions for the period of May 15-26, 2006. Courtesy of Dr. Mingshun Jiang, University of Massachusetts/Boston (http://www.harbor1.umb.edu/).

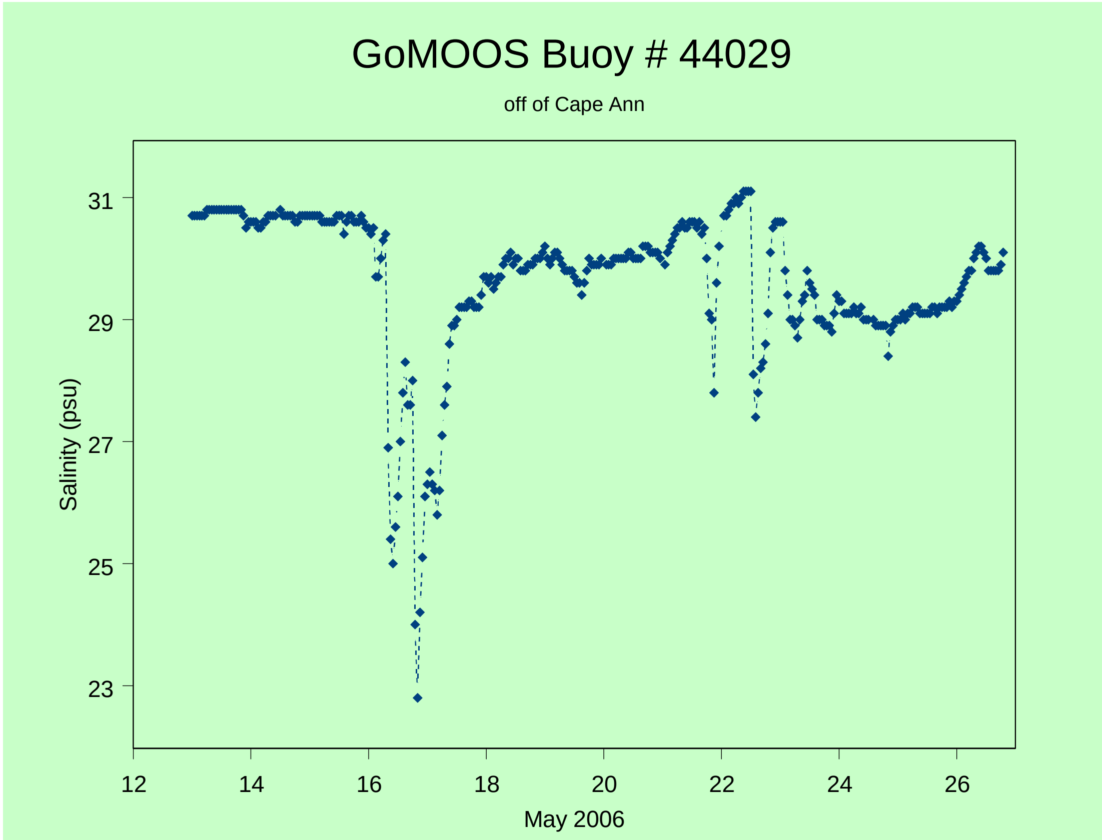

Figure 4. Surface salinity plot of Massachusetts Bay water south of Cape Ann (42.52 N, 70.57 W) from the Gulf of Maine Ocean Observing System's Buoy. A strong Merrimack plume signature is evident in the salinity traces between May 16-18, and again during the 21st and 22nd. http://www.ndbc.noaa.gov/station_page.php?station=44029

Effects on Property and Infrastructure

The most visible impact of the May 2006 event was extensive flooding throughout the region which caused significant property damage, especially in the North Shore and Merrimack River Valley regions. Rivers and streams overflowed their banks and caused extensive damage to an estimated 14,000 homes in the Commonwealth. High groundwater levels also resulted in thousands more homeowners with damage from flooded basements and yards. The strong currents swept docks, trees, and other debris downstream, further damaging docks and marinas along the river extending as far down as Newburyport. Newspaper and television reports highlighted numerous other impacts of the flooding, including major road and highway washouts, loss of power and other utilities in several communities, and damaged crops. Fortunately, no bridges failed and only one dam partially collapsed (Millbrook Dam in Rockport) but potential structural damage from the storm has yet to be fully realized.

A Major Federal Disaster Declaration was issued by President George W. Bush for those most impacted by the severe flooding beginning on May 12, 2006. The President's action makes federal disaster aid available to affected individuals and businesses in Essex, Middlesex and Suffolk Counties. For details about federal aid, flood recovery and cleanup tips, emergency contacts, and information about contributing to the flood relief, go to http://www.mass.gov/recovery.)

Effects on shellfish and marine life

While the amount of trash and debris along the banks of rivers and on beaches is visible evidence of the flooding, more dangerous are the pathogens (viruses and bacteria) and toxins that have entered the coastal waters through failed sewer systems and stormwater outfalls.

Sewer system failures caused hundreds of millions of gallons of raw sewage to spill into the Merrimack River and other rivers and streams. Along the Merrimack, one sewage treatment plant failed due to flooding, and another sewer main burst due to a collapse after the surrounding soil eroded away. Numerous other sewer overflows impacted coastal communities on the North Shore. Toxins leaking from flooded cars, businesses, and homes added to the mix. During the flood event and immediately following, shellfish beds in Massachusetts were closured due to contaminated runoff for an area that extended from the New Hampshire border to Barnstable. The closure area has since been reduced and now extends as far south as Marshfield (as of May 25).

Several beaches, especially those along Plum Island, Newbury, and Newburyport remained closed through the Memorial Day weekend because of concerns for public health and safety. The Commonwealth of Massachusetts issued warnings guarding against unnecessary exposure to flood waters, especially children, citing the potential of contamination from oil, gasoline, and sewage.

At the same time, Massachusetts enacted a red tide closure of shellfish beds from the New Hampshire border to Duxbury. The recent weather conditions have created conditions similar to what occurred during the extensive 2005 red tide (*Alexandrium fundyense*) outbreak: 1) an abundance of *Alexandrium* cysts in the central Gulf of Maine, 2) heavy rainfall and associated nutrients that *Alexandrium* cells feed on, delivered to coastal waters, and 3) northeast winds that push red tide cells towards shore where they feed on nutrients. There may not be a repeat of last year's extended closures due to the cloudy, cool weather that may have hindered *Alexandrium* growth, and persistent southwest winds could blow the cells offshore. However, on May 24, MWRA *Alexandrium* monitoring showed an exceedance of the Caution Level threshold near the MWRA outfall 9.5 miles out in Massachusetts Bay.

Impacts from the large freshwater plume coming out of the Merrimack River on coastal marine life are unknown. Many species, including larval young, may have suffered mortality. Marine life will likely recover, although it may be slow in some locations depending on residual pollutants. Normal salinity levels should return in a few weeks.

Planning for Future Events

The long term impacts of the May 2006 flood begin with infrastructure repairs. Such 100-year rain events can cause flooding that is difficult to plan for and requires expensive infrastructure enhancements to prevent. The high costs of prevention raise some public policy questions about alternatives. Immediate repair to ruptured and failed sewer lines and systems is ongoing and in many cases completed, but the question of how to mitigate damage in areas prone to flooding even under lesser storms is a pressing concern. Specifically, what do we do differently with respect to stormwater and wastewater management in the future?

An initial approach being pursued by many communities is to plan for future events by managing new and existing development in smarter ways. By better planning at the local level through the development of floodplain and stormwater management plans and through the implementation bylaws, zoning regulations, and other local mechanisms, we can limit or prevent development in floodplains and improve the management of stormwater. Such locally implemented and controlled tools allow communities to help steer development to areas less prone to hazards damage and to enhance the capacity of stormwater and wastewater systems to handle significant rain events.

The amount of impervious cover (including streets, roofs, and parking lots) has a significant impact on flooding and local water quality. The Massachusetts Bays Program estimated that nearly 20 percent of the land within the 50 communities of the Massachusetts Bays region is covered by impervious surface (*State of the Bays Report*, 2004). Studies[2] have found that a watershed with more than 10 percent of its land area covered by impervious surface will suffer from degraded water quality due to poorly-treated storm runoff. Impervious surfaces also keep rainwater from infiltrating the ground, leading to greater volumes of water directly entering stormwater systems and nearby rivers and streams, exacerbating flooding conditions. It is essential that design and management of new and existing impervious surfaces maintain the natural hydrology of the landscape. Low Impact Design (LID) techniques provide local decision makers with tools to do just that. The Massachusetts Bays Program will continue to work with other federal, state, and local partners to help communities adopt LID and smart growth tools to help mitigate the effects of polluted runoff and flood events (see http://www.mass.gov/czm/smartgrowth/index.htm).

To maintain public health and safety and our valuable marine resources, Massachusetts needs more resources dedicated to marine monitoring. As we continue to deal with both the long and short-term impacts of the May 2006 flood, we are reminded of the very real and significant threats to both human health and our valuable coastal resources. Current resources do not allow scientists and managers to meet the need for more contemporary and comprehensive understanding of coastal systems targeting impacts of events such as the May 2006 floods. A dedicated marine monitoring program would allow the development of baseline conditions, as well as timely information, to allow decision makers to understand what areas are being impacted and when conditions worsen or improve. The Massachusetts Bays Program will continue to call for such a marine monitoring effort.

For information on flood recovery assistance, please visit www.mass.gov/recovery

[2] Center for Watershed Protection. 1998. Rapid Watershed Planning Handbook – A comprehensive Guide for Managing Urban Watersheds. Ellicot City, MD. 51 pp.